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(54) Inspection Apparatus for Surface Defects

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Specifications

1. Title of invention: Inspection apparatus for surface defects

2. Scope of Patent Claims

(1) An inspection apparatus for surface defects which is equipped with: a vertical irradiation means which vertically irradiate a sample and illuminates it; an oblique irradiation means which irradiates a sample at an oblique angle and illuminates it; an image pickup means which picks up an image via receiving the light reflected on the above-mentioned sample in the vertical direction of said sample and picks up an image; and a comparison circuit which compares image signal/s containing dust and pinholes obtained from the above-mentioned image pickup means via the vertical irradiation and illumination from the above-mentioned vertical irradiation means with the image signal containing dust only obtained from the above-mentioned image pickup means via oblique irradiation and illumination from the above-mentioned oblique irradiation means, and selects the image signal corresponding to pinholes.

(2) The inspection apparatus for surface defects described in Item 1 of the Scope of Patent Claims, characterized in that [it adopts a design] in which the wavelength of the light illuminated by the above-mentioned vertical irradiation means differs from the wavelength of the light illuminated by the above-mentioned oblique irradiation means, and that it is provided with the multiple image pickup means described above in such a way that reflected light can be received from a sample surface with each of the wavelengths described above.

3. Detailed description of the invention

This invention concerns an inspection apparatus for surface defects which inspects depressed defects, such as pinholes, etc., present on a faceplate of a sample, such as a semiconductor wafer, etc.

As shown in Figure 1, pinhole 4 and dust particle 5 are present on the surface of sample 1. Pinhole 4 is, for example, a small hole produced in SiO_2 film 3 when forming SiO_2 film 3 on Si-substrate 2 via surface oxidation. As shown in Figure 2, when forming Al vapor-deposited film 6 on this via vacuum deposition of aluminum, only the pinhole 4 area experiences short-circuiting of Al vapor-deposited film 6 and Si-substrate 2, becoming defective. Therefore, it is necessary to distinguish pinhole 4 from dust particle 5 and inspect pinhole 4 only.

Conventionally, when inspecting dust particle 5 and pinhole 4, the method shown in Figure 3 has been employed. Light from illumination source 7 is vertically irradiated via condenser lens 8, half mirror 9, and objective lens 10, and the reflected light from the surface of sample 1 is detected by image pickup device 11 via objective lens 10. In this method, when a TV camera is used as the image pickup device, for

Translator's note: Quadrant layout in the translation is approximate, since the number of characters in a translated word cannot be the same as the number of characters comprising a Japanese word and the word order is different between the English and Japanese languages as well. For example, the lower left column of this page in the Japanese original includes up to the line "3. Detailed description of the invention," which is shown in the lower right column in the above translation.

example, both dust particle 5 and pinhole 4 are detected as images having the same brightness as shown in Figure 4, so that it is impossible to do what is required, to detect pinhole 4 only.

As mentioned above, if dust is present, it is simultaneously detected when inspecting pinholes, which is a disadvantage.

The purpose of this invention is to eliminate the above-mentioned disadvantage of the conventional technology, and to provide an inspection apparatus for surface defects which enables detection of pinholes only.

That is, with this invention, dust and pinholes on the same surface of a sample are detected by illuminating them via vertical irradiation, and then the dust only is detected via oblique irradiation. By comparing the detected images of both of these, the pinholes only can be selected.

The following is an explanation of this invention, referring to specific embodiments.

Figure 5 is a method for detecting dust only via oblique irradiation.

The surface of sample 1 is irradiated obliquely from illumination sources 12 and 13 via condenser lenses 14 and 15, and diffused light is detected by image pickup device 11 via objective lens 10.

Figure 6 shows the principle of detecting dust only via oblique irradiation. When light 16 is irradiated obliquely onto the surface of sample 1, diffused light 17 from pinhole 4 is not converged by objective lens 10 because it is nearly specular. But dust particle 5 has an irregular shape, so that diffused light 18 scatters and spreads, and is converged by objective lens 10. In areas with no dust or pinholes, all [the light] reflected is specular, so that only diffused light from the dust can be detected.

Figure 7 shows a method for detecting pinholes only.

Sample 1 is vertically irradiated and illuminated by illumination source 7 via condenser lens 8, half mirror 9, and objective lens 10, and is obliquely irradiated by illumination sources 12 and 13 via condenser lenses 14 and 15. Shutters 19, 20, and 21 have been inserted into each light path. First, vertical irradiation is provided by closing shutters 20 and 21 and opening shutter 19, and pinholes are detected by image pickup device 11. Next, oblique irradiation is provided by closing shutter 19 and opening shutters 20 and 21, and then dust only is detected.

When a TV camera is used as the image pickup device, the images detected have two-dimensional brightness; and with vertical irradiation, the dust and pinholes detected are dark. On the other hand, with oblique irradiation, diffused light from dust is detected, so that the dust detected is bright. Figure 8 is an electric circuit block diagram for implementing the example shown in Figure 7. 11 is a TV camera, 22 is a binarization circuit, 23 is an inverter, 24 and 25 are AND gates, 26 and 27 are memories, and 28 is an EXOR gate (exclusive OR). Image signals detected by TV camera 11 are binalized via binarization circuit 22. Binarization circuit 22's output at the time of vertical irradiation by opening shutter 19 is stored in memory 26 via AND gate 24. Next, binarization circuit 22's output at the time of oblique irradiation by opening shutters 20 and 21 is stored in memory 27 via inverter 23 and AND gate 25. Inverter 23 is inserted in order to coordinate the binary signal logic, since the "bright" and "dark" of the image signals are reversed between the vertical irradiation and oblique irradiation. AND gates 24 and 25 are synchronized with shutters 19-21, so that when shutter 19 opens, AND gate 24 opens, and when shutters 20 and 21 open, AND gate 25 opens. Single images taken by the TV camera are stored in memories 26 and 27; and since vertical irradiation and oblique irradiation cannot be provided simultaneously, binarized image signals are temporarily stored. By adopting the exclusive OR for the two memories 26 and 27 via EXOR gate 28, the area of difference between the memories, i.e., the pinhole only, can be detected.

In the embodiment in Figure 7, inspection is time-consuming because vertical irradiation and oblique irradiation cannot be provided simultaneously, requiring images to be taken at the same location twice. An embodiment which allows simultaneous vertical and oblique irradiation is shown in Figure 9.

Sample 1 is vertically irradiated by vertical irradiation 29 and oblique irradiation 30 and 31, and is detected by image pickup devices via objective lens 10. Here, light with different wavelengths, wavelength λ_1 for vertical irradiation 29, and wavelength λ_2 for oblique irradiation 30 and 31,

are used; and detection is performed by the separate image pickup devices, respectively. The reflected light of the vertical irradiation and diffused light of the oblique irradiation pass through objective lens 10 at the same time, but they can be separated by inserting dichroic mirror 32. With dichroic mirror 32 having the characteristic of transmitting wavelength λ_1 and reflecting wavelength λ_2, the images detected by the two image pickup devices 11a and 11b—the image at the time of vertical irradiation and the image at the time of oblique irradiation—can be simultaneously input.

Figure 10 is a block diagram of the electric circuit used for implementing the embodiment shown in Figure 9. Although its principle is the same as that in Figure 6, it requires a total of two image pickup devices 11a and 11b for binarization circuits 22a and 22b, respectively, but does not require memory, since there is no need to temporarily store images.

[The example in] Figure 9 can be achieved using visible light for vertical irradiation with wavelength λ_1 and infrared light for oblique irradiation with wavelength λ_2, and using an ordinary TV camera for visible light for image pickup device 11a and an infrared TV camera for image pickup device 11b. A photomultiplier, photodiode, etc., which can sense the two wavelengths λ_1 and λ_2 may also be used for both image pickup devices 11a and 11b.

In this way, even if there is dust on the sample surface, pinholes only can be detected.

As shown in the explanation given above, according to this invention, by providing vertical irradiation and oblique irradiation, required detection of pinholes only can be performed with certainty, without detecting dust, even if dust is present on the sample surface.

4. Brief explanation of drawings

Figure 1 is an explanatory drawing of a dust particle and pinhole on the surface of the sample. Figure 2 is an explanatory drawing of a defect. Figure 3 is an explanatory drawing of the conventional technology. Figure 4 is an example which describes the detecting of a pinhole and dust particle. Figure 5 and Figure 6 are both explanatory drawings of this invention. Figure 7 and Figure 9 are configurations, each explaining an embodiment of the inspection apparatus for surface [defects] according to this invention. Figure 8 and Figure 10 are both diagrams of the electric circuitry of the inspection apparatus for surface [defects] of this invention.

Legend
7, 12, 13 ... illumination sources
8, 14, 15 ... condenser lenses
9... half mirror
11a, 11b ... image pickup devices
19, 20, 21 ... shutters
32 ... dichroic mirror

Figure 1

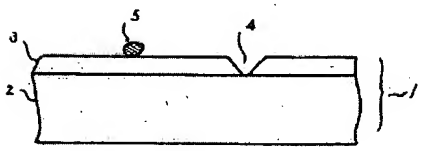
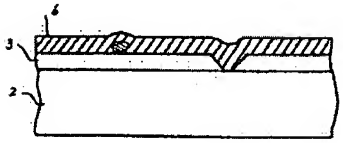


Figure 2



Agent: Patent agent Toshiyuki Usuda

Figure 3

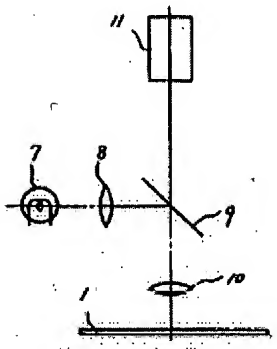


Figure 4

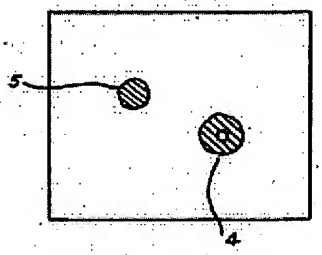


Figure 5

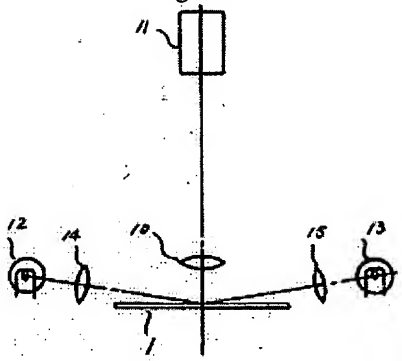


Figure 6

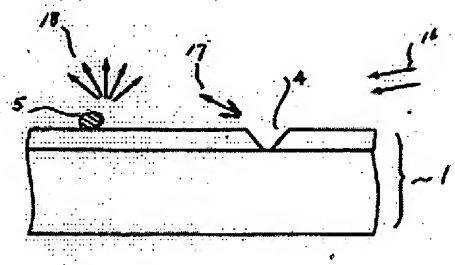


Figure 7

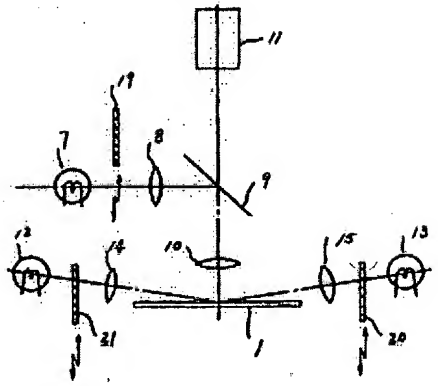


Figure 8

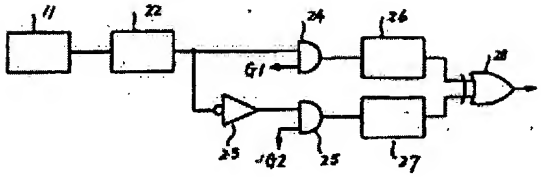


Figure 9

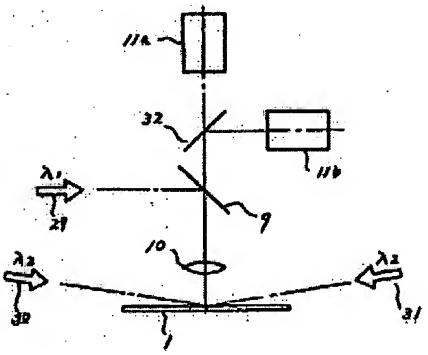


Figure 10